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WHEN AMERICA MAKES, AMERICA WORKS: A SUCCESSFUL PUBLIC-PRIVATE 3D PRINTING (POSTPRINT)

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14. ABSTRACT (Maximum 200 words) America Makes is the National Additive Manufacturing Innovation Institute, a public-private partnership led by the National Center for Defense Manufacturing and Machining (NCDMM), a not-for-profit 501(c)3 organization. The vision for America Makes is to accelerate additive manufacturing (AM) innovation to enable widespread adoption by bridging the gap between basic research and technology commercialization. America Makes fosters collaboration between its more than 170 member organizations, which include large and small businesses, universities, community colleges, economic development organizations, manufacturing extension partnerships (MEPs), federal laboratories and other federal partners. Membership has grown by about 40 percent annually, and more than 60 members are small businesses.				
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When America Makes, America Works

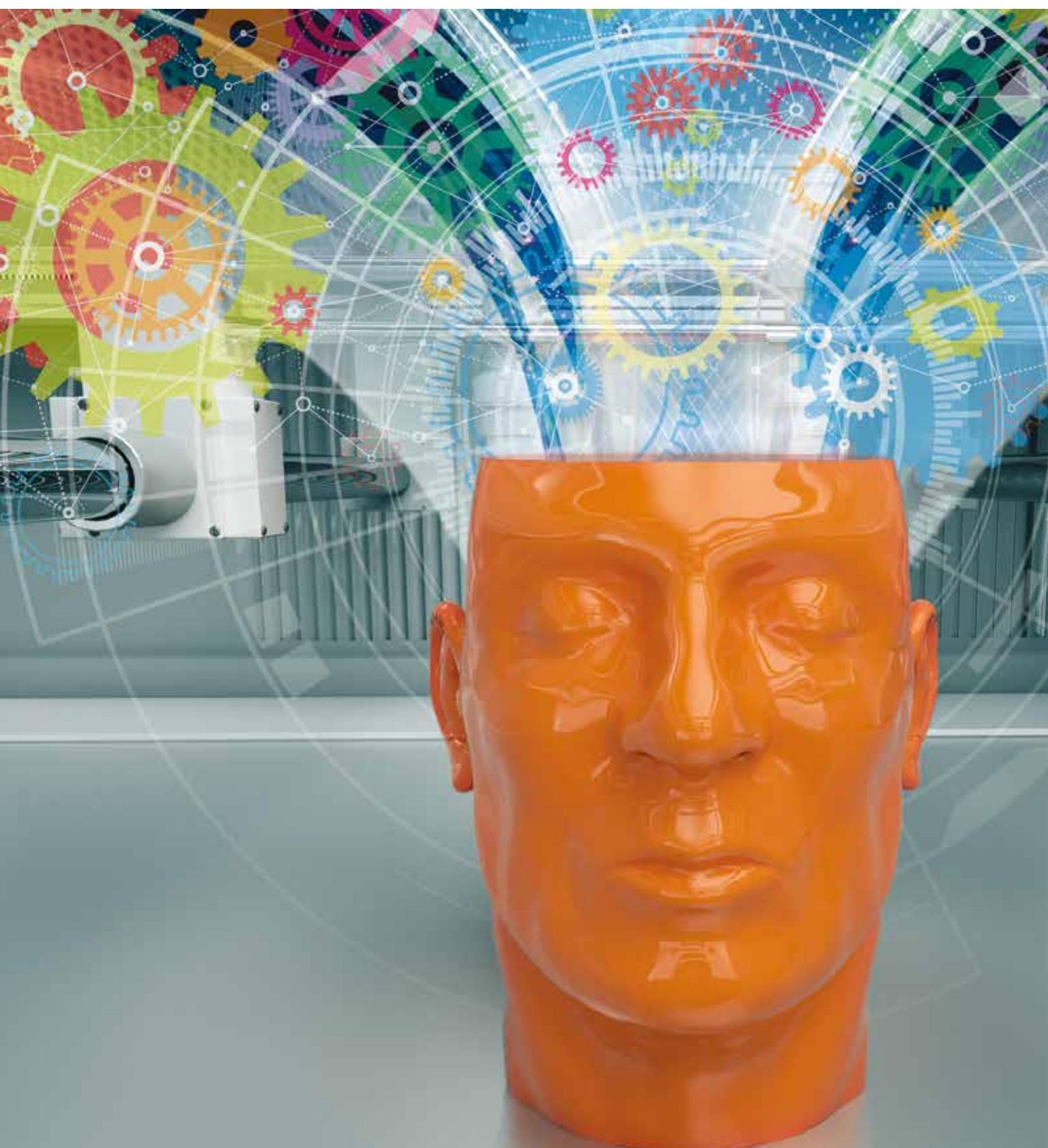
A Successful Public-Private 3D Printing (Additive Manufacturing) Partnership

Jennifer Fielding, Ph.D. ■ Ed Morris ■ Rob Gorham ■ Emily Fehrman Cory, Ph.D. ■ Scott Leonard

America Makes is the National Additive Manufacturing Innovation Institute, a public-private partnership led by the National Center for Defense Manufacturing and Machining (NCDMM), a not-for-profit 501(c)3 organization. The vision for America Makes is to accelerate additive manufacturing (AM) innovation to enable widespread adoption by bridging the gap between basic research and technology commercialization.

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Fielding is the government program manager for America Makes and a branch technical adviser within the Air Force Research Laboratory Manufacturing and Industrial Technologies Division at Wright-Patterson Air Force Base in Dayton, Ohio. **Morris** is vice president and director of America Makes within the National Center for Defense Manufacturing and Machining (NCDMM) in Youngstown, Ohio. **Gorham** is the director of operations for America Makes within the NCDMM. **Fehrman Cory** is the deputy program manager for America Makes from the Air Force Research Laboratory Manufacturing and Industrial Technologies Division at Wright-Patterson. **Leonard** is a program management consultant with D.K. Jones Consulting LLC in Beavercreek, Ohio, and is an advisor to the government partners for America Makes and other Manufacturing Innovation Institutes.



America Makes Vision:

Accelerate additive manufacturing innovation and enable widespread adoption by bridging the gap between basic research and technology development and deployment

The institute's Innovation Factory headquarters was launched in September 2012 in Youngstown, Ohio. The institute quickly finalized its operating structure and membership agreement in November 2012, and this includes the successful intellectual property model still in use today. The institute continues to expand. In 2015, America Makes launched a pilot satellite center at the University of Texas in El Paso, a center of innovation for additive manufacturing in a region of opportunity for economic and workforce development.

The Public-Private Partnership— A Model for Innovation

A combined public and private investment is the most efficient and effective method to enable U.S. federal agencies, industry, and academic institutions to collaborate and coordinate on the three main focus areas of America Makes: Technology Development, Technology Transition and Dissemination, and Workforce Development. The public-private partnership is implemented through a Cooperative Agreement with the Air Force Research Laboratory on behalf of the Office of the Secretary of Defense, Manufacturing and Industrial Base Policy. America Makes' federal partners include the Department of Defense (DoD), the Departments of Energy, Commerce, and Education, as well as NASA, the National Science Foundation, Federal Aviation Administration, and the Food and Drug Administration (FDA).

The America Makes public-private partnership is a collaboration that goes well beyond co-investment of funds. The organizational structure of America Makes embeds dozens of government employees in the ongoing operation of the institute. For example, the Air Force program management team collaborates with the America Makes management team almost daily to work on both strategic and tactical level issues. In addition, the organization receives advice on program-level issues from the Government Partners Advisory Committee, a team of about 16 government subject-matter experts representing all of America Makes' government partners. Finally, government personnel participate on America Makes' numer-

ous advisory groups and working groups that address topics such as technology roadmapping, weapon system sustainment, and technical standards.

The public-private partnership enabled America Makes to convene diverse groups to address broad needs of the additive manufacturing community. For example, America Makes facilitated the creation of a joint DoD technology roadmap for additive manufacturing through a series of workshops that brought together experts from the Air Force, Army, Navy, and the Defense Logistics Agency. Seeing the critical need for industry-led standards, America Makes is partnering with the American National Standards Institute and all relevant standards development organizations to coordinate the development of industry standards.

Another important aspect of the America Makes public-private partnership is that it allows all government services and agencies to work with America Makes to address their needs relative to 3D printing research, development and workforce training. Several government organizations already have worked with America Makes this way by funding more than \$20 million in agency-directed projects. Projects are competed among members to identify the best team and technical approach. If the project has potential for broad commercialization, industry may match the government funding with a significant cost share. Many projects address the needs of multiple government organizations, and those organizations may choose to leverage their efforts by co-funding a project while avoiding redundant investments. Funding organizations maintain full control of the project's statement of objectives, proposal selection, and project oversight. Because of the America Makes process for solicitations, projects frequently are performed by multiple team members representing all essential supply chain levels, and this accelerates technology transition and creation of production supply chains.

For industry partners, the ability to spread the cost share across the members of the project team further reduces their individual risk and increases their return on investment. Several large business members report they are realigning their internal research and development investments with the America Makes technology investment roadmap. This business model aligns well with the DoD's Better Buying Power 3.0 initiative to increase the productivity of industry independent research and development and contracted research and development. With the combined and integrated public and private investments, America Makes is establishing a culture of collaboration that is developing into a strong engine for innovation and technology commercialization in the United States.

Technology Development

Additive manufacturing, more commonly known as "3D Printing," is a suite of emerging technologies to fabricate metallic, plastic, ceramic and electronic parts for applications as diverse as lightweight aerospace structures and custom biomedical implants, all using a layer-by-layer technique, in which

material is placed precisely as directed from a 3D digital file. Additive manufacturing is a game-changing technology for both the U.S. manufacturing economic engine and the defense industrial base that allows production of new and enhanced products that cannot be made using traditional manufacturing techniques. Additive manufacturing is an enabling technology for the military, potentially allowing spare parts to be built or platforms to be repaired in-theater, which will make possible last-minute design adjustments to respond to mission changes, and reduce the cost of building complex parts.

America Makes has a portfolio worth more than \$96 million in public and private funds invested in advancing the state-of-the-art in additive manufacturing. To achieve these technical advancements, project teams frequently are self-organized as supply chains, including technology innovators, material suppliers, equipment producers, and large system integrators. This team structure facilitates technology transition into production by ensuring that requirements are understood at all levels in the supply chain. Here are just a few examples of recent technology development and dissemination success stories:

Impacting Medical and Aerospace Sectors with High Performance Polymers. A team led by Northrop Grumman, in partnership with small business and part manufacturer Oxford Performance Materials (OPM), demonstrated a high-performance polymer as a viable material choice for air and space vehicle applications. OPM's material became the first polymeric additively manufactured material to receive FDA approval for cranial, facial and spinal implants (2015) and the results from this project are on track for transition into major defense system programs in 2016.

Bringing Additive Manufacturing Options to Small Machine Shops. Small business member Optomec, along with Mach-Motion and TechSolve, developed a modular kit to retrofit any computer numerical control (CNC) machine to create a hybrid machine with additive manufacturing capabilities. Now these hybrid CNC/additive manufacturing machines can perform both additive and traditional subtractive processes on a metal part. This achievement

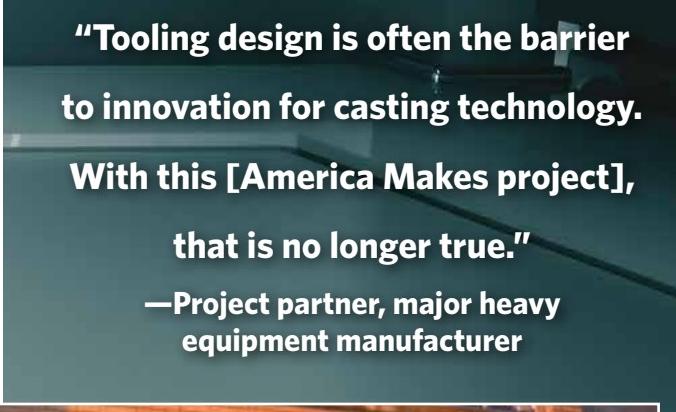
America Makes has more than 170 organizational members, comprising:

- Large Businesses
- Small businesses (over 60)
- Universities
- Community colleges
- Economic development organizations
- Federal laboratories
- Other federal partners



"America Makes is the strongest public-private partnership I've seen in my 32-year career."

—Engineering director of a major aerospace company



"Tooling design is often the barrier to innovation for casting technology. With this [America Makes project], that is no longer true."

—Project partner, major heavy equipment manufacturer

The America Makes Innovation Factory is a center for immersive training for the 3D printing workforce.

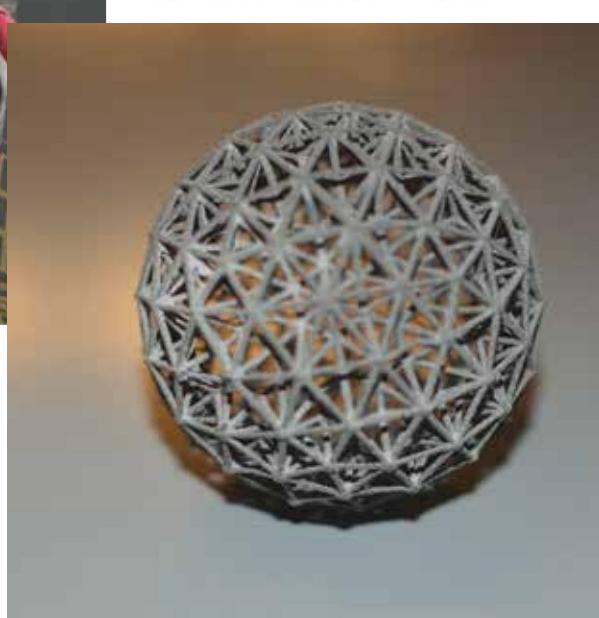
All photos courtesy of the National Center for Defense Manufacturing and Machining





Left: A possible future engineer studies a model of an envisioned Mars-based habit as it is constructed by a 3D printer.

Below: 3D printing can produce complex shapes and structures that cannot be made using traditional manufacturing methods. A lattice stucture is ideal for maintaining performance with lighter weight.



"America Makes is invaluable for helping community colleges understand what workforce skills are in demand."

—Vice president for Strategic and Institutional Development at a regional member community college

"America Makes is having an extraordinary impact on our region. Youngstown has a new confidence. Local government is working with universities and local businesses more. Youngstown State University is proud to have America Makes nearby, and it is now part of our student recruiting story."

—Jim Tressel, president, Youngstown State University

enables manufacturers and machine shops to adopt additive manufacturing technologies at a fraction of the cost—for a 60 percent savings compared to purchasing a new additive manufacturing machine with equivalent capabilities. This product now is commercially available and has been purchased by DoD suppliers.

Additive Manufacturing Transforms Metal-Casting Industry. Youngstown Business Incubator, in partnership with Youngstown State University in Ohio and major industrial partners, developed a methodology for additive manufacturing of sand-cast molds, built regional supply chains for multiple materials, developed two domestic sources for resins and cleaners, and reduced the cost of printing materials by more than 80 percent. The team partnered with the American Foundry Society to reach more than 800 metal-casting companies with the technology. Technology transition applications include fuel system components for multiple major defense and automotive part suppliers. An automotive part was especially difficult to produce as an eight-piece assembled sand cast tool, prone to breakage upon assembly. The additively manufactured sand core tool was able to be produced as one part and improved yield from 12 percent to more than 99 percent, while also reducing the manufacturing lead time by 70 percent. Adoption of this technology is making these small manufacturers globally competitive for producing advanced, complex metal castings.



Members of America Makes value the opportunities to network and build project teams and supply chains.

Workforce Development and Educational Outreach

Additive manufacturing is a fast-growing manufacturing trend and calls for new ways to educate and train both the workforce. America Makes has partnered with stakeholders to build a comprehensive workforce and education roadmap to address training needs. "America Makes is invaluable for helping community colleges understand what workforce skills are in demand," said the vice president for Strategic and Institutional Development at a regional member community college.

Every America Makes technology development project includes an integrated workforce activity with clear training deliverables. Some of the many workforce development success stories include:

America Makes partnered with Deloitte Consulting, Marquette University, Oak Ridge National Laboratory and 3D Systems to create a free Massive Open Online Course in additive manufacturing business fundamentals. It is designed to help educate the market on the business drivers of additive manufacturing. More than 14,000 participants have been trained so far.

America Makes partnered with the Veterans Administration for a Prosthetics and Assistive Technologies Challenge, which enabled a wide range of additively manufactured devices to be developed to help injured veterans conquer daily challenges. This led to a follow-on project funded by Google.org to develop training for returned military veterans to learn the basics of creating personalized assisting technologies using 3D printing, rapid prototyping, and scanning technologies.

America Makes launched the first-ever additive manufacturing certificate program in partnership with the Milwaukee School of Engineering and the Society of Manufacturing Engineers. The certificate program expands the students' knowledge

of additive manufacturing technologies and provides a portable, authenticated career credential and has awarded more than 200 certificates so far.

Regional and Supply Chain Impact

The creation of America Makes accelerated the clustering of advanced manufacturing and economic development within the region. Youngstown Business Incubator (ranked the Number One university-

associated business incubator in the world by the University Business Incubator Index), in partnership with America Makes, received funds for renovating a fifth building within its downtown complex for incubation of additive manufacturing startups. This economic revitalization and the local opportunities it has created are drawing key startups and entrepreneurs to the area and building the regional supply chain.

"America Makes is having an extraordinary impact in our region," said Jim Tressel, president of Ohio's Youngstown State University. "Youngstown has a new confidence. Local government is working with universities and local businesses more. Youngstown State University is proud to have America Makes nearby, and it is now part of our student recruiting story."

Conclusion

America Makes has shown its ability to convene the additive community within a public-private partnership model to drive an innovation economy forward for the nation. Additive manufacturing is a game-changer because it brings a whole new set of rules to multiple industry sectors, from aerospace and defense solutions to lifesaving medical applications. It also is an incredibly powerful teaching tool to reinvigorate Science, Technology, Engineering and Mathematics—or STEM—education in the United States. The opportunity of additive manufacturing along with the success of America Makes' public-private partnership structure is playing a critical role in developing additive manufacturing for advanced defense capabilities and growing a manufacturing-driven economy. For more information, see www.americamakes.us.



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